California Energy Commission

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PEER REVIEW OF THE MICROTURBINE AND INDUSTRIAL GAS TURBINE PROGRAMS:

THE PIER PROGRAM ACTIVITIES

http://www.energy.ca.gov/index.html

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Background

- Established by California AB 1890 and SB 90 in 1996-97 and implemented in 1998.
- $62.5 million collected annually from investor-owned electricity utility ratepayers for "public interest" energy research, development and demonstration (RD&D) projects.

PIER Program Mission

- Conduct public interest energy research that seeks to improve the quality of life for California's citizens by providing environmentally sound, safe, reliable and affordable energy services and products.

- "Public interest energy research" includes the full range of RD&D activities that will (1) advance science or technology (2) is not adequately addressed by competitive or regulated markets.

- PIER is <u>not</u> a commercialization program.

Technical Subject Areas

- Environmentally Preferred Advanced Generation (EPAG)
- Energy Systems Integration
- Renewable Energy
- Industrial/Agricultural/Water Efficiency
- Building Efficiency
- Energy-Related Environmental

EPAG's Objectives

Advance the technical and market status of EPAG technologies so that installed systems will achieve:

- A low cost of electricity that is competitive with the grid
- Low environmental impact, especially low air emissions
- High reliability, availability, maintainability, durability, and usability
- Market connection.

Implied objectives:

- High fuel-to-electricity conversion efficiency
- Fuel Flexibility
- Dispatchability.

EPAG's Technology Solutions

Short term

- Advance Reciprocating Internal Combustion Engines (ARICE)
- Interconnection standards and technology

Medium term

- Fuel cells, micro & small gas turbines (<20 MW)
- Standardized testing protocols

Longer term

- Hybrids with fuel cells and/or micro/small turbines
- Combined heat and power
- Other high efficiency (fuel to electricity) systems.

EPAG Program Coordination with Department of Energy (DOE)

- Joint advisors on program goals and targets.
- Coordination of turbine projects.
- DOE funding of ASERTTI Proposal:

  Collaborative National Program for the Development and Performance Testing of Distributed Power Technologies with Emphasis on Combined Heat and Power Applications

Current EPAG Turbine Projects

Microturbine Generators, Fuel Cells & Hybrid Systems Development

University of California, Irvine

PIER Funding: $1,409,000

Develop standardized testing and reporting procedures for microturbine generators, develop steady-state analytical tools for fuel cells, and develop dynamic modeling capabilities for fuel cell and fuel cell/turbine hybrid systems.

Current EPAG Turbine Projects

Analyses and Technology Transfer for Fuel Cells/MTG Hybrids

UC Irvine, SoCal Edison, M-C Power, Siemens-Westinghouse/ NREC, Energy Systems Services

PIER Funding: $306,000 / Match Funding: $14,000

New computer-based modeling tools were developed to improve understanding of the operation of fuel cell systems and fuel cell/ microturbine hybrid systems. Simulation models were developed for three components: a tubular SOFC, a reformer that converts hydrocarbon fuels to hydrogen-containing gas for use in the fuel cell, and a microturbine.

Current EPAG Turbine Projects

Micro-Turbine Generator (Distributed Generation)

Edison Tech. Solns, UC Irvine, Energy Sys. Serv., CAMS, Paragon, Capstone Turbine, Bowman Turbines

PIER Funding: $500,000 / Match Funding: $1,500,000

To test small gas turbines for DG applications, a Capstone (28 kW) and two Bowman turbines (35 and 60 kW) were tested at UCI. Both Bowman units had component failures and high noise levels. The Bowman 60 kW and Capstone 28 kW had NOx and CO emissions at or below SCAQMD limits. The Capstone unit had power quality measurements that met standards of the Institute of Electronics Engineers.

Current EPAG Turbine Projects

Develop & Demo a Modular Flex-Microturbine That Runs on Low-Energy, Low-Pressure Biomass Gases

FlexEnergy, Capstone Turbine, NREL, UC Davis

PIER Funding: $984,000 / Match Funding: $2,546,000

Design and develop a small microturbine that will run on different biomass fuels. Demonstrate it operating on biogas derived from anaerobic digestion of livestock manure, producer gas generated from thermal gasification of orchard and forest residues, and biogas from a landfill gas recovery system.

Current EPAG Turbine Projects

Testing, Optimization & Demo of an EPAG Microturbine

ALM Turbine, Inc.

PIER Funding: $2,867,000 / Match Funding: $3,405,000

Use several novel technologies - predominantly developed by Russian engineers now living in the US - to develop a 300kW gas turbine which has high efficiency over a broad power range, low emissions, and low cost. Most gas turbines have high efficiency only at full power.

Current EPAG Turbine Projects

Solid Oxide Fuel Cell / Microturbine Generation Hybrid

Edison Tech. Solns, Siemens-Westinghouse, NERC, UC Irvine, Energy Sys. Serv.

PIER Funding: $2,000,000 / Match Funding: $14,900,000

Demonstrate proof-of-concept for a pressurized SOFC and microturbine generator into a 250 kW hybrid unit. Expected fuel-to-electricity efficiency is 60% with very low NOx and greenhouse gas emissions.

Current EPAG Turbine Projects

Ultra-Low NOx Combustor for 13.5 MW Turbine Generator

Alzeta Corp.

PIER Funding: $2,404,000 / Match Funding: $1,077,000

Develop an end-use, ultra-low emission combustor that can be retrofitted on a 13.5 MW Solar gas turbine. The technology avoids the high cost of exhaust gas cleanup, and should be adaptable to other sizes of turbines and other OEMs.

Current EPAG Turbine Projects

Low NOx Gas Turbine Combustors for Distributed Power Generation

Alzeta Corp.

PIER Funding: $879,000 / Match Funding: $675,000

Continue development of the Gas Turbine Semi-Radiant Burner for gas turbine applications, to reduce NOx and CO emissions to <2 ppm. Develop a design integrating control and hardware interfaces for use in commercially available turbines.

Current EPAG Turbine Projects

Low NOx Gas Turbine Combustors for Distributed Power Generation

Alzeta Corp.

PIER Funding: $1,312,000 / Match Funding: $2,740,000

Test an ultra-low NOx (2 ppm) combustor, developed on a prior PIER project, on an operating microturbine. Develop prototype combustors for industrial-scale engines. Develop manufacturing methods that will reduce combustor cost. The intent is to eliminate the need for costly post-combustion clean-up.

Current EPAG Turbine Projects

Catalytic Combustor-Fired Gas Turbine for Distributed Power & Cogeneration

Solar Turbines, Catalytica Combustion Systems, UC Irvine

PIER Funding: $815,000 / Match Funding: $773,000

Develop the component technologies and engineering design of a multi-can catalytic combustion system for use in 5.2 MW and 4.6 MW gas turbines. Design specification include 5 ppm NOx emissions without water or steam injection and on post-combustion NOx clean-up. This is the first phase of a three phase project.

Current EPAG Turbine Projects

Durability of Catalytic Combustion Systems
Catalytica Combustion Systems, Inc.

PIER Funding: $1,316,000 / Match Funding: $3,030,000

One-year reliability and durability demonstration of catalytic combustion technology on a 1.5 MW gas turbine. The objective of this technology is pollution prevention rather than exhaust gas clean-up.

Current EPAG Turbine Projects

Xonon Ultra-low NOx Combustion in Small Multican Turbine

Catalytica Energy Systems

PIER Funding: $2,998,000 / Match Funding: $3,394,000

Develop and demonstrate multi-can catalytic combustion on a gas turbine. The results should be adaptable to other OEMs. The technology has been demonstrated on the single-can combustors of small turbines, but control systems need to be developed for larger multi-can turbines. This is the second phase of a three phase project.

Current EPAG Turbine Projects

Catalytic Combustor-Fired Industrial Gas Turbine

Solar Turbines Inc.

PIER Funding: $3,000,000 / Match Funding: $1,623,000

Implement cost-effective, low-emission, catalytic combustion in a 5.3MW gas turbine (with applicability to a 4.6 MW turbine). Catalytic combustion avoids costly post-combustion (exhaust) cleanup. This project extends a current PIER effort involving Solar and Catalytica, and will speed introduction of the technology into the California niche market.

Current EPAG Turbine Projects

Partial Oxidation Gas Turbine for Electricity & H2 Production

Gas Technology Institute

PIER Funding: $1,618,000 / Match Funding: $1,618,000

Develop and demonstrate a gas turbine with the combustor replaced by a unique partial oxidation reactor. The turbine exhaust can be used as fuel gas for fuel cells, furnaces or boilers, resulting in high-efficiency, low-emissions hybrid or CHP systems.

Current EPAG Turbine Projects

500kW Zero-Emission Gas-Fired Power Plant
Clean Energy Systems Inc.

PIER Funding: $2,003,000 / Match Funding: $2,046,000

Demonstrate the reliability of a unique, zero emissions, 500kW gas generator as it drives a steam turbine to generate electricity at a commercial power plant in Contra Costa County.